学校编码：10384

学号：23320071152184

厦门大学

硕 士 学 位 论 文

宽带无线自组织网的物理层差错控制机制的研究与实现

Research and Implementation of the PHY Error Control Mechanism on Broadband Wireless Ad Hoc Network

许双燕

指导教师：石江宏

专业名称：通信与信息系统

答辩日期：2010年5月

厦门大学学位论文原创性声明

本人呈交的学位论文是本人在导师指导下,独立完成的研究成果。本人在论文写作中参考其他个人或集体已经发表的研究成果，均在文中以适当方式明确标明，并符合法律规范和《厦门大学研究生学术活动规范(试行)》。

另外，该学位论文为(   )课题(组)的研究成果，获得(   )课题(组)经费或实验室的资助，在(   )实验室完成。(请在以上括号内填写课题或课题组负责人或实验室名称，未有此项声明内容的，可以不作特别声明。)

声明人(签名):

年　月　日

厦门大学学位论文著作权使用声明

本人同意厦门大学根据《中华人民共和国学位条例暂行实施办法》等规定保留和使用此学位论文，并向主管部门或其指定机构送交学位论文(包括纸质版和电子版)，允许学位论文进入厦门大学图书馆及其数据库被查阅、借阅。本人同意厦门大学将学位论文加入全国博士、硕士学位论文共建单位数据库进行检索，将学位论文的标题和摘要汇编出版，采用影印、缩印或者其它方式合理复制学位论文。

本学位论文属于:

(　　)1.经厦门大学保密委员会审查核定的保密学位论文，于　年　月　日解密，解密后适用上述授权。

(　　)2.不保密，适用上述授权。

(请在以上相应括号内打“√”或填上相应内容。保密学位论文应是已经厦门大学保密委员会审定过的学位论文，未经厦门大学保密委员会审定的学位论文均为公开学位论文。此声明栏不填写的，默认为公开学位论文，均适用上述授权。)

声明人(签名):

年　　月　　日

摘　要

无线自组织网是一组自治的无线节点相互协作而形成的独立于固定的基础设施并采用分布式管理的网络。由于它具有组网灵活、容易实现等优点，在军事通信、应急通信等方面有广阔的应用前景。宽带无线自组织网是一种无线通信和计算机网络相结合的网络，它的应用环境复杂，信道误码率高，数据传输速率高，实时性好，要求有较高的可靠性。因此相对于一般通信系统，有效的差错控制方案对于宽带无线自组织网而言显得更为重要。

CTC与Turbo码相比具有编码效率高，相同复杂度译码器下纠错性能好，译码迭代次数少，译码时延小等优点，同时消除了尾比特对译码性能的影响。文中通过仿真验证，得到译码迭代次数相同时，CTC的性能略优于Turbo码。

本文利用Matlab搭建了完整的HARQ系统仿真平台，以CTC码为前向纠错码，在COST-207 TU信道下，研究分析了不同的设计参数、不同实现方案对于系统性能的影响。综合各性能影响参数，探讨了两种HARQ自适应方案：结合星座图重构的Type-II HARQ；结合交织重组、星座图映射的Type-III HARQ（RV=1）系统。通过仿真比较得到两个方案的性能相当，当采用QPSK调制时，Es/No=0dB，误码性可达到10-3，吞吐量约为0.6。Type-III HARQ（RV=1）系统实现相对简单，需要的缓存较少，其误码率及吞吐量性能略逊于Type-II HARQ，但差距不超过0.3dB。

最后，完成了基于OFDM的HARQ系统的FPGA设计。该系统以CTC码为前向纠错码，重传策略采用Type-III (RV=1)，码合并采用比特级的似然比合并方式，并结合交织重组与星座图重构技术。文中对各主要模块的FPGA实现进行了详细的说明，包括CRC编解码、发送缓存模块、CTC编译码、OFDM调制解调、接收缓存模块等。特别是发送缓存模块及接收缓存模块，由于涉及HARQ重传控制，接收合并及缓存管理等功能，文中根据自组织网的空中接口及模块实现的可行性对其进行了详细的阐述，通过仿真验证模块工作正常。

关键词：无线自组织网；CTC；HARQ；FPGA

Abstract

Wireless Ad Hoc network is a kind of peer-to-peer network. With the advantages of network flexibility and easy realization, it has bright prospects in military communications, emergency communications, etc. Wireless Ad Hoc network incorporates wireless communications networks and computer networks. Compared with the general communication system, more effective error control scheme is required in broadband wireless Ad Hoc networks.

Compared with Turbo code, CTC is charactered with higher coding efficiency, better error correction performance, fewer decoding iterations and lower decoding delay with the same decoder complexity. In the paper, it has been verified by simulation that CTC's performance is better than Turbo codes with the same number of decoding iterations.

In this paper, a complete HARQ system simulation platform is built by Matlab, in which CTC serves as the FEC code. Also a research is peroformed on the effects of different design parameters and implementation options to system performance under COST-207 TU channel. Two kinds of adaptive HARQ schemes are proposed: Type-II HARQ system which makes use of constellation rearrangement and Type-III HARQ (RV=1) system which combined with interleaving reorganization and constellation rearrangement. The performances of two schemes are similar in a BER performance of 10-3 and throughput of about 0.6, when Es/No=0dB and QPSK modulation is choosed. The implementation of Type-III HARQ (RV=1) systems is relatively simple, requiring less buffer while the bit error rate and throughput performance slightly are inferior to Type-II HARQ's, but the gap does not exceed 0.3dB.

Finally, the design of OFDM-HARQ system is completed based on FPGA with CTC as the FEC code and Type-III (RV = 1) as retransmission scheme. Moreover LLR is taken for code combination as well as the techonology of interleaving reorganization and constellation rearrangement are adopted in the final system. The FPGA implementation of the mainly modules is elaborated in the paper, including the CRC encoding and decoding, send buffer, CTC encoding and decoding, OFDM modulation and demodulation, the receive buffer module. Expecially, since the combination module of send/receive buffer greatly is associated with HARQ retransmission control, a detailed analysis is carried out in this paper based on wireless interface of adhoc network and the the viability of implementation.

Keywords: Ad Hoc; CTC; HARQ; FPGA

参考资料

[1]Kallel. S. Analysis of a Type-II Hybrid ARQ Scheme with Code Combining [J]. IEEE Trans. Commun, Aug.1990,Vol.38,Issue8,pp. 1133-1137.
[2]Kallel.S. Complementary Punctured Convolutional (CPC) Codes and Their Applications [J]. IEEE Trans. Commun. June, 1995, Vol.43,Issue6, pp.2005-2009.
[3]Krishna R. Narayanan. A Novel ARQ technique using the Turbo Coding Principle [J]. IEEE Communications letter. March 1997, Vol, 1, NO.2.
[4]Douglas N. Rowitch. and L. B. Milstein. On the performance of hybrid FEC/ARQ systems using rate compatible punctured turbo (RCPT) codes [J]. IEEE Transactions on Communications. June 2000, vol.48, NO.6, pp.948-959.
[5]Abdel-Ghani A. Daralseh, Carl W.Baum. Methods for Packet combining in HARQ system over burst channels [J]. Mobile networks and applieation 2(1997), pp.213-224.
[6]Hans-Jurgen Zepernick. Reliability and Throughput Analysis of ARQ Schemes in Burst Error Channels [J]. ISIT 1997,Ulm,Germany, June29-July4.
[7]3GPP TR25.835,Report on Hybrid ARQ Type II /III.
[8]3GPP TSGRI (#14)-00-0869, Hybrid ARQ methods for FDD in Release 2000, Nokia.
[9]3GPP TR25.848, Physical layer aspects of UTRA High Speed Downlink Packet Access (Release 4), 2001.03. [S].
[10]田耘, 徐文波, 张延伟. 无线通信FPGA设计[M]. 北京: 电子工业出版社, 2008.
[11]C. Berrou, A.Glavieux, P.Thitimajshima, Near shannon limit error-correcting coding and decoding: Turbo-codes [J]. in Proc.of IEEE International Conference on Commun, Geneva, Swtizerland, May, 1993, pp.1064-1070.
[12]Lin Nan Lee, A.Roger Hanunons. Application and standardization of Turbo codes in third-generation high-speed wireless data services [J]. IEEE Trans, Veh. Techn. Vol.49, No.6, Nov.2000, pp.2198-2207.
[13]Berrou C, Jezequel M, Douillard C ,et al. The Advantage of Non-Binary Turbo Codes[C]. ITW2001, Caims, Australia, Sep.2- 7, 2001.
[14]吴宇平. WiMAX系统中卷积turbo码的应用研究[D]. 哈尔滨工程大学硕士论文, 2008.
[15]802.16 IEEE Standard for Local and metropolitan area networks Part16: Air Interface for Fixed Broadband Wireless Access Systems. [S].
[16]邵长虎. 循环卷积Turbo码译码研究[D]. 上海交通大学硕士论文, 2007.
[17]Motorola. Details of high speed downlink packet access[S]. 3GPP RP-000126, TSG-RAN#7. March 13-15, 2000.
[18]3GPP TR 25.848. vl.0.0 (2000-05), Technical Specification Group Radio Access Network; Physical Layer Aspects of UTRA High Speed Downlink Packet Access (Release 2000), Mar.2001.
[19]杨大成等. cdma2000lx移动通信系统[M], 机械工业出版社, 2003.
[20]陈庆春. 基于码合并的混合差错控制及相关理论研究[D]. 西南交通大学博士研究生学位论文, 2000.
[21]郭梯云,邬国扬,李建东. 移动通信[M]. 修订版. 西安电子科技大学出版社, 2000. pp. 90-100.
[22]DAVID CHASE. Code combining a maximum-likelihood decoding approach for combining an arbitrary number of noisy packets [J]. IEEE Transactions on communications, vol.com-33, no.5, pp.385-393, 1985.
[23]Youngku Choi, Sunghyun Choi. A novel ARQ strategy for wireless mobile IP network. Proc.JCCI2005, Daegue, Korea, 2005.4.
[24]Joe K wak. Physical Layer ARQ [J]. IEEE 802.16abc-01/57rl, Nov12-16, 2001.
[25]LIU Fang KONG Jian. Performance of Hybrid ARQ Schemes for OFDM Systems [J]. 中国邮电高校学报（英文版）,2004 No.04, P.67-78.
[26]3GPP TR25.835 Vl.0.0, Physical Layer Aspects for Evolved UTRA, P.8-10.

[27]T. Kumagai, M. Mizoguchi, T. Onizawa. A maximal ratio combining freguqncy diversity ARQ scheme for OFDM signals. in Proc. of the ninth IEEE Symposium on Personal Indoor, and Mobile Radio Communications, vol.2, pp. 528-532, 1998
[28]Harvind Samra, Zhi Ding. Retransmission diversity schemes for multicarrier modulations. IEEE Transactions on Wireless Communications, vol.5, no.5, pp.1142-1147, May 2006
[29]LEI S, LAU K N. Performance analysis of adaptive interleaving for OFDM systems. IEEE Transactions on Vehicular Technology, 51(3), pp.435-444, 2002
[30]程锦霞,周世东,姚彦,一种新型的基于OFDM系统的自适应HARQ方案,通信学报26(l2),pp. 126-130, 2005.12
[31]BERROU C, GLAVIEUX A, THITIMAJSHIMA P. Near Shannon limit error-correcting coding and decoding: Turbo-codes [C]. Proc ICC ’93. Geneva, Switzerland: [s.n.], 1993.
[32]PYNDIAH R, PIEART A, GLAVIEUX A. Performance of block Turbo coded 16-QAM and 64-QAM modulations[C]. IEEE GLOBECOM ’95. New York: IEEE, 1995.
[33]GOFF L S, GLAVIEUX A, BERROU C. Turbo-codes and high spectral efficiency modulation[C]. IEEE SUPERCOMM/ICC ’94. New Orleans: [s.n.], 1994.
[34]Panasonic. Enhanced HARQ Method with Signal Constellation Rearrangement [R]. TSGR1#19 (01)0237.
[35]Wengerter C.Advanced Hybrid ARQ Technique Employing a Signal Constellation Rearrangement [J].Vehicular Technology Conference,2002.Proceedings.VTC 2002-Fall.2002 IEEE 56th Volume 4,24-28 Sept.2002 Page(s):2002-2006 vol.4
[36]GU Xin-yu, LI W Y, NIU Kai, et al. A universal soft output algorithm for M-QAM demapper[C]. Proceedings of ICCC ’2004. Beijing: ICCC, 2004.
[37]GU Xin-yu, WANG Yi-chen, YU Xiao-bo, et al. Advanced hybrid ARQ technique employing a signal constellation rearrangement based on 64-QAM [J]. Journal of Electronics & Information Technology, 2005, 27(11): 1686-1690.
[38]Yongzhong Zou, Jiangbo Dong, Daoben Li. A novel HARQ and AMC scheme using space-time block coding and turbo codes for wireless packet data transmission [J]. Proc. ICCT 2003, vol.2,9-11 pp. 1046-1050, April 2003.
[39]Woo Tae Kim, Sang Jae Bae. Performance of STBC with Turbo Code in HARQ scheme for mobile communication systems [J]. Proc, ICT2003, vol.1, 23 pp.85-89, March 2003.
[40]Ch Wengerter, A. Elbwart, E.Seidel. Advanced Hybrid ARQ Technique Employing a Signal Constellation Rearrangement [J]. Vehicular Technology Conference, 2002.Proceedings.VTC 2002-Fall.2002 IEEE 56th Volume 4, 24-28 Sept.2002 Page(s):2002-2006 vol.4
[41]Xilinx. Product Specification: IEEE 802.16e CTC Encoder v2.1 [Z]. April 2, 2007.
[42]Xilinx. Product Specification: IEEE 802.16e CTC Decoder v3.0 [Z]. October 10, 2007.
[43]Xilinx. Fast Fourier Transform v5.0 [Z]. http://www.xilinx.com.